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Simulation evaluation of the costs of adapting the low density traffic line to practical exploitation

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Abstract

The issue of adapting the lines excluded for economic reasons from exploitation for a longer period of time by railway administration boards becomes in many countries, including Poland, a question of importance. Local governments, which own the areas where such railroads are located, are facing the problem of opening these lines but having in mind the improvement of life conditions of local communities. The actual task is grounded, however, in assessing the costs of opening – revitalizing of such a line. This article's aim is to present a simulation tool for assessing the cost of adapting a low density traffic line to practical exploitation.

Keywords: local railway lines; low density trafic lines; revitalization

1. Introduction

The notion of railways, in Poland popularly called *Low Density Traffic Lines – LDTL*, is not clearly defined (Abramow & Mazo 1996; Drewnowski & Siedlecki 2007, Galayema, Imovilli, & Sciutto 1995). The management boards of railways from Europe and other countries have their own regulations in this field and still various indications – parameters decide on the assignment of a given railway to the low density traffic lines.

We may distinguish three different LDTL segments:

- North American freight railway, single-track lines, mostly for exporting purposes, frequently crossing under populated areas,
- European secondary passenger lines,
- mixed lines in Europe, Asia and Australia.

In specialist literature the low density traffic lines are described as:

- in Europe: low traffic railways lines, low density traffic lines, secondary railways lines, regional railway lines, local railways lines,

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- in North America: secondary and branch rail lines (feeder lines to main corridors/trunk lines),
- in the Commonwealth of Independent States (CIS) countries: local lines, low density lines, low traffic lines.

While looking through the legal regulations concerning the railways, it is difficult to come across the term "low density traffic lines". Generally is lack the regulations in that matter (see Table 1).

Table 1. European regulation according to *LDTL*

Country	Genarally lack	Kind of traffic	Importance of line	Velocity	Intensity of traffic
Austria			X		
Denmark		X	X		
Finland	X				
France		X		X	X
Holland	X				
Luxemburg	X				
Germany		X		X	X
Norway	X				
Poland	X				
Slovakia			X		
Switzerland	X				
Sweden	X				

In Poland, the Regulation of the Minister of Transport and Maritime Economy (OMTME, 1998) classifies the railroads in 4 categories:

- main railway lines – Category 0
- crucial – Category 1
- secondary – Category 2
- local significance – Category 3

Each category has relevant exploitation parameters: transport load, maximum velocity, maximum velocity for freight trains and allowed axle pressure. This classification is shown in the Table 2 (OMTME, 1998).

Table 2. Polish classification of the railroads

No	Railway line category	Transport load T [Tg/year]	Maximum velocity v_{max} [km/h]	Maximum velocity for freight trains v_t [km/h]	Allowed axle load P [kN]
1	Main railway lines (0)	$T \geq 25$	$120 < v_{max} \leq 200$	$80 < v_{max} \leq 120$	$P \leq 221$
2	Crucial (1)	$10 \leq T < 25$	$80 < v_{max} \leq 120$	$60 < v_{max} \leq 80$	$210 \leq P < 221$
3	Secondary (2)	$3 \leq T < 10$	$60 < v_{max} \leq 80$	$50 < v_{max} \leq 60$	$200 \leq P < 210$
4	Local significance (3)	$T < 3$	$v_{max} \leq 60$	$v_{max} \leq 50$	$P < 200$

In general, in the EU or in other countries there is no unambiguous classification, which would enable to categorize a certain line as LDTL. Therefore, the literature offers more qualitative than quantitative terms for describing this kind of lines (Abramow & Mazo 1996; Drewnowski & Siedlecki 2007, Galayema et.al. 1995). The low density lines are identified as those with low intensity of traffic (less than 2 trains an hour) and with limited financial outlays needed for maintenance. Taking into consideration that in some countries the LDTL represents as much as 25% of the total length of railway tracks, it is proven this issue is not of marginal significance and taking it up is well-grounded

2. Low Density Traffic Lines –Problems of Local Governments

The process of road transport's development observed in the western Europe since the mid-20th century provoked in the beginning of the 1960s a decrease in rail transport, both regarding the freight an passenger transport (Massel & Wołek, 2007). Bearing in mind the economic reasons, above all, the railway administration boards in countries such as Germany, France, Holland or Great Britain began in the 1960s the process of reorganization, which involved in the first place the local lines called the low density traffic lines. In its first stage, the reorganization concerned closing of selected lines and later – their liquidation. The waking up appeared only in the beginning of the 1990s and a classic example of it is Germany, where in the period of 1994-1996, a complex revitalization program for the local railways was created. It included, among other issues, opening of the regional railways by creating a favorable legal and organizational framework and, perhaps what is even more important, rules of financing such activities. This program is based on a regionalization process, which understands handing over the means and entitlements to the transport to the Lands (and, consequently, to local governments) and is carried on with great dynamics and success until now. In Poland, in the beginning of the 1990s, as part of the railways' reorganization, actions aiming towards shutting off and liquidation of local railways (low density traffic lines) were undertaken. It is worth mentioning that this process in Poland was brutal and turbulent. As the result of incautious actions, in the year 2004 the length of the railways was only 77,2% of the length from the 1990, where at the same time the average for 25 EU Member states was 92%. Obviously, the more damaged railways were the local lines. In other countries of the so-called Eastern Bloc, the reduction of railways was not as significant as in Poland. The actions taken by the Polish Government in the beginning of the XXI century, which aimed at joining the European Union, forced the administration and the legislative bodies to improve the living conditions of local communities, among other matters. One of the elements of these actions was the improvement of mobility of these communities, which is inseparably connected with creation of possibilities to travel within a given region and from one region to another. A weak and inefficient road infrastructure in Poland is not capable of fulfilling this task, therefore rail transport with existing infrastructure was taken into consideration, after conducting necessary modernization and reconstruction works. In the year 2000 legal framework was created (AoCRP, 2000), which enabled to start the process. The article 18 section 6 of the act (AoCRP, 2000) says: "PLK S.A. may transfer local importance railway lines to territorial self-governing units or sell to undertakings by means specified in the regulations on commercialization and privatization of state owned enterprises, upon concurrence of the minister relevant to transport." Formal conditions needed to start the revitalization process of local low density traffic lines were created, however no clear mechanism of the process' financing was provided. Handing over the entitlements for creating structures of regional railway transport to the local governments started, on the other hand, the process of handing over a part of the Polish Railway Lines (PKP PLK S.A.) company's property, useless for the company.

Regrettably, local governments are not fully prepared for opening lines and managing this property. One of the elements in the process of taking over the properties by local governments is the problem of costs related to revitalization of the taken railway. The assessment of the costs connected to the adaptation of a railway, which has not been exploited for several years, taking into consideration not only the cost of adjusting the rail infrastructure to the requirements of the Office for Railway Transport (UTK) but also the cost of purchasing the rolling stock and its further maintenance, is crucial in the process of making the decision regarding taking over of a given line. So far no tools for the assessment of these costs were available. Works started several years ago (Chudzikiewicz, Uhl, & Pietrzyk, 2009; MSSKL, 2008) allowed for creating a simulation tool, which may be used for assessing the adjustment and revitalization costs of the existing rail infrastructure and low density traffic lines for current exploitation.

3. Simulation Package

3.1. Object's Model

The research on a real model may be carried out according to various criteria, essential for the researcher. Therefore, the same real system may be characterized by different nominal models, depending on the task defined. For every nominal model we may construct many equivalent mathematical models, depending on the method of analytical physics, in the description of movement, certain assumptions and simplifications of mathematical nature, outside conditions acting on the object and many more. The most significant criterion while choosing the nominal model is to consider the properties of the real system, which, in the discussed case, have a decisive impact on the analyzed phenomenon. Thereby, all irrelevant features, which may complicate the analysis, shall be omitted.

Taking the considered case, we shall be interested in a model understood as a tool for foreseeing the behavior of the **system User – Railway – Vehicle (URV)** for the low density traffic lines. The notion of the word 'system' is understood as a certain 'creation' *built of subsystems (models), which interact with each other, however these* *interactions have a crucial impact on the system's properties as a whole*. It was assumed that the model of this system should include in its structure the following elements of the real system:

- structure of a railway line
- track and its structure
- system of traffic control
- means of transport
- traction system
- engineering objects
- financing structure of all the above mentioned elements,

and suggested the following models, which describe the system:

- model of the railway
  - model of the rail track
  - model of the system of traffic control
  - model of the ground infrastructure
- model of the vehicle
- model of the operation
- model of the costs

In the process of modeling and designing the simulation model, a unified language Unified Modeling Language (UML) was used, designed for the process of modeling IT systems.

3.2. Simulation Model

The structure of the simulation model is shown on Figure 1. With use of the UML V.2.0 programming language, a numerical package was designed, which allowed to map and model the infrastructure of a given line.

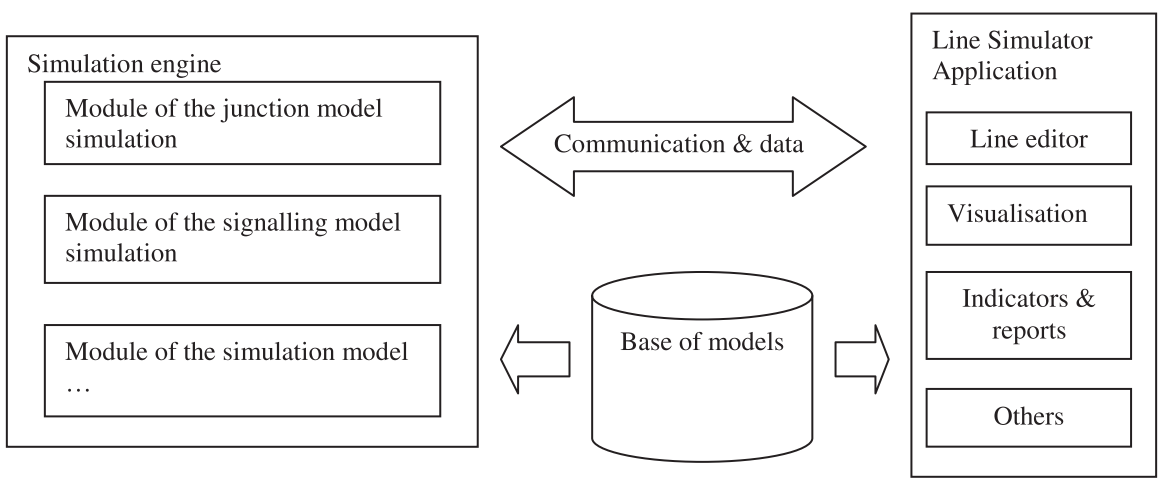


Figure 1. Structure of the simulation model.

A demonstration window of the user's interface enabling to model a line is shown on Figure 2. After definition of the elements of infrastructure the user can model the trains and establish for each of them time-table.

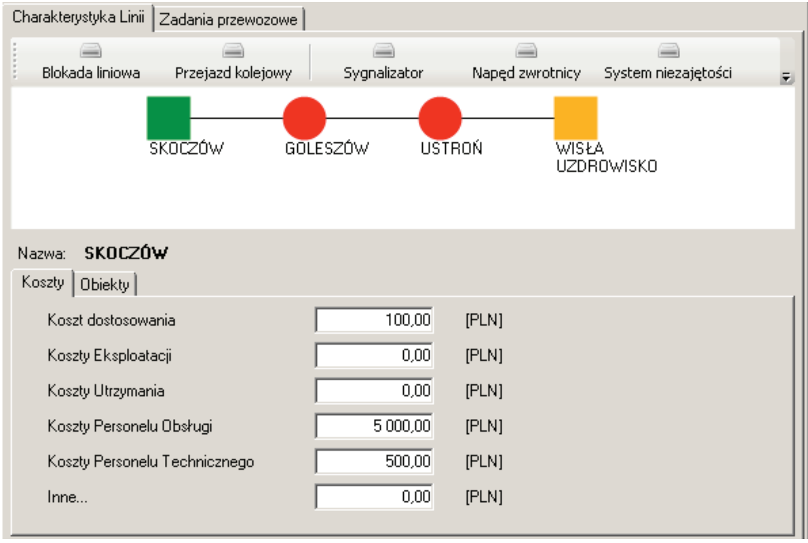


Figure 2. Example of the windows for line definition and description of their characteristics.

For that one can use special window in the system (Fig. 3a and 3b). In the next step, by assuming an indispensable rolling stock for the transport operation, the regimes of its exploitation and the timetable, the user may carry out a process of simulation of the adjustment and exploitation costs of the line in a given time framework. The user's interface has been elaborated according to the Windows philosophy, which allows users with knowledge of basic IT tools to use it.

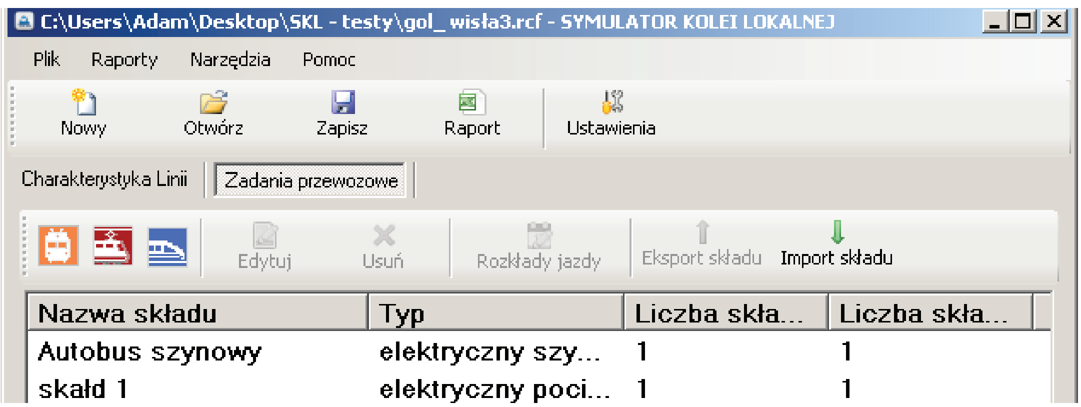


Figure 3a. Window for definition of the trans.

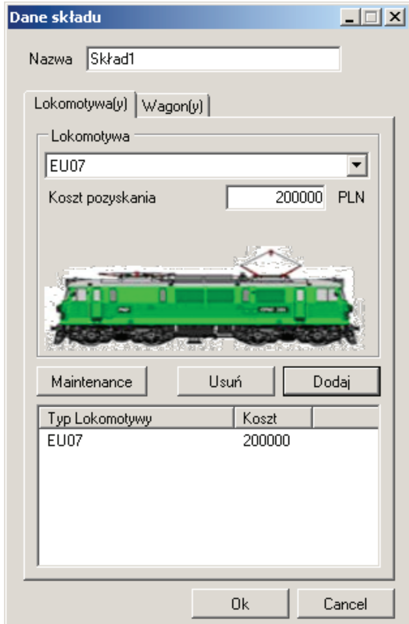
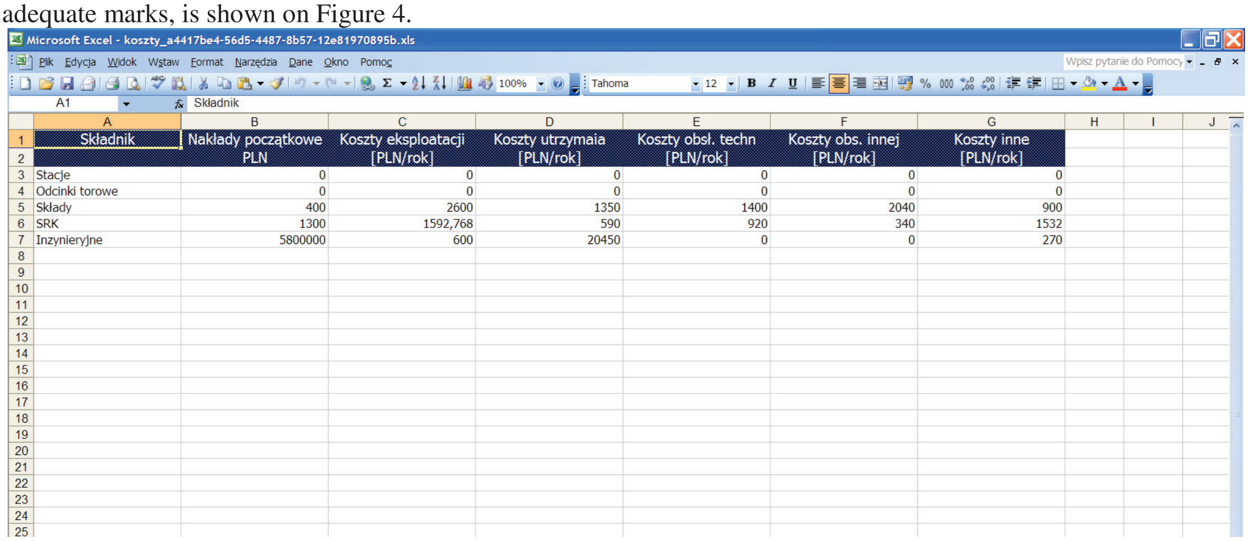


Figure 3b. Window for choosing type of rail vehicle.

3.3. Demonstration Results

The outcome of the simulation is the calculated cost of revitalization (adjustment) and further exploitation of a given section of line, including such components as: initial outlays, exploitation costs, maintenance costs, technical service costs, other service costs and other costs. The costs include such elements of the line as: stations, track sections, rolling stock (number of carriages), SRK devices and engineering objects such as: bridges, viaducts, culvert. A demonstration of a final report regarding the costs, written in the Excel format and designed with adequate marks, is shown on Figure 4.



Składnik	Nakłady początkowe PLN	Koszty eksploatacji [PLN/rok]	Koszty utrzymaia [PLN/rok]	Koszty obsł. techn [PLN/rok]	Koszty obs. innej [PLN/rok]	Koszty inne [PLN/rok]
Stacje	0	0	0	0	0	0
Odcinki torowe	0	0	0	0	0	0
Składy	400	2600	1350	1400	2040	900
SRK	1300	1592,768	590	920	340	1532
Inzynieryjne	5800000	600	20450	0	0	270

Figure 4. Example of the costs report

The users can obtained more information from simulation about the simulation's line using the tool. After the tests process the simulation tool will be give local governments.

4. Conclusions

In the EU countries, including Poland, new technical and organizational solutions in the rail transport are under a constant research. Such solutions would ensure a substantial decrease in the expenditures related to the exploitation of the railway lines with low density of traffic.

One of the elements of this research is the attempt at handing over these lines to local governments, which do not have the possibility to make a financial evaluation of such a step and, at the same time, fear taking decisions connected to taking over of the lines.

In many cases, the decision on the organization of the railway transport and the low density traffic lines is based on deliberations and opinions created by intuition of the policy-makers, however without having a thorough technical and economic analysis. The reason for such a situation is the time needed for collecting the necessary data, which would enable the creation of models for certain railway line. These models should consider not only the above-mentioned aspects but also carrying out the required simulations and drawing up suitable forecasts, economic above all. This article presents a simulation tool designed to support the decision making process in such cases.

The created simulation package is characterized by a user friendly and transparent interface as well as allows for a considerable time shortening needed for a financial evaluation of the task related to liquidation or revitalization of a low density traffic line.

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References

Abramow A. P., Mazo L. A. (1996). Opredielenie ekonomiczeskich pokazatelej eksploatacji malodelatelnych rzeleznodoroznych linii. Westnik *WNIISZT. No3*. In Russian

(AoCRP) Act dated September 8, 2000 on commercialization, restructuring and privatization of „Polish State Railways" State Enterprise (Official Journal 84 fig. 948 from 12.10.2000 with further amendments).

Chudzikiewicz, A., Uhl, T., Pietrzyk, A. (2009). *Modelowanie procesów zachodzących na liniach małoobciążonych*. IV Międzynarodowa Konferencja Naukowa SYSTEMY LOGISTYCZNE – TEORIA I PRAKTYKA, Rawa Mazowiecka, Poland. In Polish

Drewnowski A, Siedlecki P. (2007). Ocena ekonomiczna linii kolejowych o małym natężeniu przewozów. *Zeszyty Naukowe US, 423. Problemy Transportu i Logistyki, 3*, 17-26. In Polish

Galaverna, M., Imovilli, A., Sciutto, G. (1995) *Low-cost operation of secondary lines: the Italian situation, Electric Railways in a United Europe*, International Conference, Issue , 27-30 Mar 1995, pp. 20 – 22.

Massel A., Wołek M. (2007). Wybrane zagadnienia procesu rewitalizacji regionalnych linii kolejowych. *Transport i Komunikacja*, 6, 26-30. In Polish

(MSSKL) Modelowanie i symulacja systemu kolei lokalnej jako narzędzie wspierające podejmowanie decyzji w zakresie zarządzania rozwojem regionów. Projekt Rozwojowy nr N R10 0019 04. (2008-2010). finansowany ze środków MNiSzW. Wydział Transportu Politechniki Warszawskiej. In Polish

(OMTME) Ordinance of the Minister of Transport and Maritime Economy dated September 10, 1998 on the technical conditions of rail constructions and their localization (Official Journal dated December 15, 1998).